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ABSTRACT

This document reports on a conference that was convened by Educational Equity Concepts, Inc. and the New York Academy of Sciences. Disciplines that were represented included child development, special education, early childhood education, sociology, psychology, physics, mathematics, assessment, teacher education, parent involvement, economics, and demographics. Chapters include: (1) "Developmentally Appropriate Ways to Expand Young Children's Understanding of the World"; (2) "Helping All Children Develop a Broad Range of Skills That Will Prepare Them for Later Competency in Science, Math, and Technology"; (3) "Using Assessment to Learn about Children's Science Learning"; (4) "Implications for Teacher Education"; (5) "Involvement of Parents and Family"; (6) "Today's Kindergarten, Tomorrow's Workplace"; and (7) "Issues for Further Exploration." A list of participants is also included. (YDS)

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Early Childhood Science Education and the Workforce of Tomorrow

A Special Report

from the

New York Academy of Sciences

and Educational Equity Concepts, Inc.

September 2000

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Early Childhood Science Education and the Workforce of Tomorrow

Edited by
Merle Froschl, Rodney W. Nichols, Lori Skopp,
and Barbara Sprung

A special Report
based on a conference convened by
Educational Equity Concepts, Inc.
and the New York Academy of Sciences

New York, New York
June 15-16, 1999

September 2000

A Science in Society
Policy Report

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Educational Equity Concepts, Inc.
114 East 32nd Street
New York, New York 10016
telephone: 212.725.1803
fax: 212.725.0947
e-mail: information@edequity.org
web address: www.edequity.org

Education Department
New York Academy of Sciences
655 Madison Avenue, 16th Floor
New York, New York 10021
telephone: 212.838.6727, ext. 630
fax: 212.355.2781
e-mail: education@nyas.org
web address: www.nyas.org

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Preface

On June 15-16, 1999, Educational Equity Concepts, Inc., and the New York Academy of Sciences convened "Educating for the Future: Connecting Kindergarten in the Year 2000 to the Workforce of 2020." The conference was supported by the National Science Foundation under an initiative entitled "Transitions from Childhood to the Workforce" (TCW). The initiative was created to foster research on children's learning in order to help children become healthy, productive citizens who are competent to join the technologically intensive workforce of the 21st century.

The conference, held at the New York Academy of Sciences in New York City, brought together a diverse group of researchers and educators representing many academic disciplines and areas of expertise—child development, special education, early childhood education, sociology, psychology, physics, mathematics, assessment, teacher education, parent involvement, economics,

and demographics. In a series of interactive panels, participants discussed six questions related to the TCW initiative. The emphasis was developmentally-appropriate science, math, and technology education, beginning in early childhood.

The conference opened up avenues for future cross-disciplinary research projects to be undertaken by the participants and others. A list of questions and issues for further exploration appears in the back of this document. The conference sharpened many questions. Despite a solid understanding of how young children learn, there is still more that we need to find out—particularly in the fields of math, science, and technology education. Moreover, issues of equity and access remain major and formidable barriers toward progress.

We look forward to a future when *all* young children will be nourished by excellent math, science, and technology education, with well-prepared teachers and developmentally-appropriate classrooms. Looking to the year 2020, we must press forward right now if we want tomorrow's workforce to have a quality educational experience today. Kindergartners are at the beginning of a journey. We can help them to achieve greatness.

MERLE FROSCHL, *Educational Equity Concepts, Inc.*
RODNEY W. NICHOLS, *New York Academy of Sciences*
LORI SKOPP, *New York Academy of Sciences*
BARBARA SPRUNG, *Educational Equity Concepts, Inc.*

Introduction

Many children attending kindergarten in the year 2000 will be entering the workforce by the year 2020. Connections between the playful learning of children and their careers are real, but little attention has been paid to them by researchers, teacher educators, practitioners, or parents. Often these connections are not addressed until much later on the educational continuum, if at all. For example, college juniors and seniors think about careers as graduation approaches and they must decide on their next steps. However, to understand how today's kindergartners can become tomorrow's productive citizens, a focus on the beginnings of learning is essential.

Although early childhood education is a young discipline (mostly developed within the 20th century), a large body of research

already exists on the developmental benchmarks all children must achieve, on the active learning style of children, on language development, and on social development. The research of Piaget and Vygotsky and the educational philosophy of John Dewey are the foundations for constructivist curriculum and the child-centered learning environment. A constructivist approach to learning provides children with an environment in which they construct knowledge through direct experience with objects and phenomena, research, and working cooperatively with others. It is a style of learning which comes naturally to most children, and is in tune both with developmentally-appropriate practice and the movement in science education toward inquiry-based learning.

> Children are learning from the moment of birth, and perhaps even before that, in utero. In terms of education in a school setting, the early childhood years (preK-grade 3) are a time of immense cognitive, social, and emotional growth. They are the years when the building blocks of the formal learning disciplines—mathematics, science, language arts/communication, social studies, art, and music are constructed through developmentally-appropriate curricular activities. These early years are also the time when children form their views of the world they live in, and their place in it.
>
> Barbara Sprung, Educational Equity Concepts, Inc.

The High/Scope Foundation's long-term study on the children who attended the Perry Preschool underscores the role of early education in the development of a productive citizenry and workforce.[1] This longitudinal study followed children who attended a high quality, child-centered active learning preschool program. The study found that at age 27, in comparison with a control group, the Perry Preschool group achieved a significantly higher

level of schooling; had significantly more home and car ownership; needed fewer social services; and had significantly fewer arrests. More recent research on brain development further confirms the importance of high quality early education.[2]

Even the best trained early education teachers may know very little about science, math, and technology, and may also have anxiety about these subjects. In fact, even in schools where constructivism and active learning are the norm, science, math, and technology may not get the attention that they deserve.

> School success is the absolute essential if children are going to join the workforce of the 21st century in 2020. There are many children in this country who don't have a ghost of a chance of making it as things stand right now – children of poverty, children from low-income families, racial minorities, foreign language speaking children. We have a crisis on our hands if we are going to accept as a challenge to bring all children into the workforce of the 21st century.
>
> Barbara T. Bowman, Erikson Institute.

The challenges of effective science, math, and technology education for young children are worst in schools where teachers are poorly trained, there is high teacher turnover, or students come from severely disadvantaged backgrounds. Indeed, the biggest challenge comes in making quality early education universal. Too many children—African-Americans, Latino/as, girls from all groups, children with disabilities, children whose first language is not English, children of poverty—do not have access to the best education we can provide. Unless we seriously address these equity and diversity issues, we may not be able to meet our workforce needs in the 21st century.

Demographics tell the tale. A recent study entitled, *Children of 2010*, reports that children of color will represent the majority of young people in the most highly populated states—Florida, California, New York, and Texas—by the year 2010; and by the middle of the 21st century people of color will represent a majority of the population of the United States.[3] In the context of science, math, and technology, these are the children who do not have equal opportunity for early preparation, advanced course work, career counseling, or other opportunities in these growing fields.

> While research has taught a great deal about quality early education programs, there has been little exploration of the role of math, science, and technology in kindergarten.
> Lori Skopp, New York Academy of Sciences

These stark demographic issues are juxtaposed against the desired attributes of the future workforce—teamwork, creative-thinking, problem-solving, strong communication skills, competence in technology. These challenges for educators, also include issues of social change as well as educational practice. But, it is not enough to discover the most effective ways to teach science, math, and technology to young children. Throughout the conference, participants returned time and again to the social issues of equity, diversity, and poverty that inhibit every aspect of educational reform.

Developmentally Appropriate Ways to Expand Young Children's Understanding of the World

Developmentally appropriate practice (DAP) was articulated in the mid-1980s by the National Association for the Education of Young Children (NAEYC). The purpose is to counter the "push down" pencil and paper curriculum that was being increasingly employed at the preschool level as a method of "school readiness." DAP is educational practice that caters to the cognitive, social, and emotional needs of individual children at varying stages of development. An early childhood classroom that follows DAP is child-centered, allowing children adequate time to explore materials, work with other children, and learn within a nurturing and supportive environment.

Standards for DAP that are geared to the developmental level and needs of the individual child are seemingly opposed to national education standards, which set fixed goals to be met by each grade level (e.g., every child will read with fluency and comprehension by third grade). In order to help teachers respond to the national standards movement, the NAEYC modified its definition of DAP in 1997. DAP now takes a more flexible approach, which acknowledges the reality of standards-based assessment while remaining true to principles of child development.

Curriculum based on DAP encompasses the following:

- clear and measurable objectives about what children need to know and flexibility for those objectives to change over time;
- methods of assessing what children already know and how that knowledge can be utilized for school success;
- conceptual frameworks to help children organize information they have learned for themselves and others;
- understanding of and attention to the emotional needs of children, the importance of their relationship with other children and adults, and knowledge of what motivates them to learn.

In a DAP classroom, a network of attachments is created through daily interactions—teacher to

> Developmentally appropriate practice exercises and challenges the learner's capacities as they emerge at a given developmental level. It encourages and helps the learner to develop a unique pattern of interests, talents, and goals. It's democratic; it gives the child a choice. It recognizes that each child learns at his or her own pace and that each has different interests, abilities, and motivations. Finally, it presents learning experiences when learners are best able to master, generalize, and retain what they learn, and can relate it to previous experiences and future expectations.
>
> Barbara D. Finberg,
> MEM Associates

child/child to teacher, child to child, teacher to family/family to teacher. Learning is viewed as a social as well as a cognitive event. The culture of the school and the culture of the home need to be understood so that families and educators can learn from each other in order to best serve the needs of the child. This is particularly important in reaching children who are at-risk. Educators must assess what children already know when they enter school. They can build upon the child's developmental competence and learn about the child's competencies by listening to their parents' assessment; and to children themselves.

The Role of the Teacher

An effective teacher is one who is well-trained, eager to connect, believes in every child's ability to learn, and is an active and self-reflective practitioner. Such a teacher conveys that she or he cares about each child as an individual, and learns to know a child within the context of his/her family and culture; makes sure that each concept being taught is understood before moving a child onto something else; and has high expectations, which are conveyed to *all* children.

Since early childhood education is a multi-disciplined endeavor, to teach effectively teachers need to acquire a broad range of academic knowledge and must have mastery of the subjects in the curriculum. Moreover, high quality preservice education is needed that teaches *how* to teach subject matter such as math, reading, and science. Teachers often find themselves in stressful and non-productive situations when the culture of the school does not support what they know to be best practice. Time must be made for ongoing professional development to keep up with changes in

the field, and to generate *new* approaches to teaching and learning. Teacher autonomy—the freedom to create curriculum that is child-centered and developmentally-appropriate—is integral to a DAP classroom. Time to plan alone, with colleagues, with parents, with children, and time to assess and reflect must be built into the culture of the school.

> It is not enough for a school building to have one or two good to excellent teachers. All children deserve a cohesive cohort of teachers who are supporting each other and who are engaged in a social endeavor of teaching and learning, and who also view themselves as learners.
>
> Jerlean E. Daniel,
> University of Pittsburgh

Inclusion

Inclusion is an integral aspect of DAP. The inclusion of children with disabilities in the early childhood community of learners is another essential aspect of developing productive citizens who will form the workforce of the future. The segregation of children with disabilities has led to low expectations on the part of teachers and parents, gender disparities (with boys being disproportionately placed in special education), high drop-out rates, and, in the long-term, low employment opportunities.

Diverse groups of children learning together builds friendship, tolerance for individual differences, empathy, and respect for democratic principles. For example, children with and without disabilities share skill learning—children with disabilities have experience in problem-solving and creative-thinking to share with peers; children with good language skills can share those skills with peers who have language delays; and peers can model positive behavior for a child with emotional or behavioral difficulties.

Looking Forward

To achieve the goal of a healthy, active, productive citizenry, *all* children entering school must have teachers who have broad-based knowledge of child development and DAP, academic competence in subject matter, and understanding of and respect for diverse cultures. The culture of the school must change so that parental insights are valued, home cultures are respected, and parents are welcomed as partners in their children's education.

Early childhood science education needs reform. The teachers' poor science and math education, lack of preservice training in how to teach science in developmentally-appropriate ways, and the fact that many early childhood teachers are female and have been socialized to think science is not for them, has resulted in a serious deficit in the curriculum. This must change. The constructivist approach to curriculum coupled with children's desire to know how things work are strong assets for science education. Teachers who are exposed to inquiry-based science workshops have the opportunity to overcome their anxieties and appreciate the value of making science an integral part of the early childhood curriculum. Parents, too, can learn how to bring science and math experiences into the everyday lives of children through simple activities using common and culturally-familiar materials.

> Exclusion from the educational mainstream is, in essence, a violation of a child's civil rights. In the year 2000, if all five-year-old children with a disability attended kindergarten class in their neighborhood school with typically developing peers, and they could be a member of an inclusive class throughout their school career, they will be better prepared for the workforce.
>
> Valerie Lava,
> Long Island University

Helping All Children Develop a Broad Range of Skills that will Prepare Them for Later Competency in Science, Math, and Technology

The idea of play as a valid form of education was first described in 1826, by Froebel, "the father of kindergarten" in his book *The Education of Man.*[9] He says "that play is the primary mode of learning for children; that understanding occurs through meaningful and multisensory experiences with the world." This mode of learning can be referred to as meaningful play—a form of play where the teacher creates an environment through which children can learn.

Although the idea of play-centered learning has existed for 170 years, play, and developmentally appropriate practice (DAP), is not yet common in many early education classrooms—particularly

beyond the preschool years. It is likely that the absence of DAP in classrooms is related to a lingering Puritanical distrust of play as time "wasted" which dates back to early notions of education in which the teacher's major role was to provide discipline. This is also attributed to an under-appreciation of the value of "hand" or "visual" knowledge.

> Often when the teacher would ask what are these shapes, and the kids would go ahead and name all the shapes, she would then say, "let me teach you about them," and with that evidence right before her would proceed with the lesson as if the kids had said, "I have no idea."
>
> Douglas H. Clements, SUNY Buffalo

Learning Through Play

Learning occurs naturally during children's play. During preschool free-play time, children spend about half of their time engaging in mathematical activities such as classification, exploring dynamics/change (addition, subtraction, etc.), numeration (counting), magnitude comparisons, spatial relations (both in terms of and apart from navigation), and the creation and exploration of shapes and patterns. Young children are good at discovering mathematical concepts about the world around them. Even without particular teacher guidance, children engage in meaningful play as they build with blocks, put together puzzles, measure and pour liquids, and discuss the world around them.

Algorithms

Children are able to combine concepts they have been taught with games they enjoy, in order to develop algorithms for mathematical concepts. For instance, a girl told her father that when her younger brother was six, she would be eight, when he was

seven, she would be nine, and so on until he was eighteen and she was twenty. When her father asked how she had figured that out, she said, "Simple, you just say, six-SEVEN-eight, seven-EIGHT-nine," and she stamped her foot on the middle number for added emphasis. Her father realized that she had combined counting, which was a skill that she had been taught, with the ditties that she sang skipping rope to figure out how to do simple addition with an algorithm for adding two. There is deep value in such self-discovered algorithms. Children who are allowed to build their own algorithms end up with higher achievement in formalized math settings.

> Young children—regardless of their socio-economic status--are already engaged in mathematical thinking. What's striking about young children are the opportunities—not the barriers—for mathematical learning. Their learning typically involves more than simple concepts that psychologists usually study.
>
> Herbert P. Ginsburg, Teachers College, Columbia University

If children are going to learn about science, math, and technology through play, then they need to be provided with playthings that will fuel their inquiry. Playthings designed for this purpose are called "manipulatives". Educators do not know precisely what makes an effective manipulative though they do know that some manipulatives succeed in transmitting information, while others do not.

One basic guideline is that manipulatives should be open-ended, yet formalized, thus allowing children to experiment, while guiding their thoughts in productive directions. One can, however, discern the traits of an effective manipulative by watching children play/interact with different objects.

Manipulatives should be designed with an eye toward mathematical concepts. Another successful characteristic of manipulatives is pleasing aesthetic design—clean lines and attractive colors tend to draw children to the material.

Computers

Computers are another type of "hands-on" educational tool to encourage technology education. To those who do not have training in child development, they may appear to be more "serious" than manipulatives, which may be seen as toys of dubious educational value. Computers should complement rather than supplant the use of manipulatives in the classroom. Young children need to focus on multisensory and three-dimensional learning experiences. Computers may also confuse young children, who have trouble determining whether or not they are, in fact, "alive". Young children go through a developmental stage of "magical thinking," in which they cannot always distinguish what is real and what is fantasy.[5] Computer programs often add to the sense of "magic", for example, on a computer a seed can grow into a flower within seconds.

> The pure pleasure of arranging forms in space and deciding what looked right and reflecting on what that meant, seeing similarities and differences from these forms, and ones in the real world, was totally involving for children, even those who were considered hyperactive and couldn't sit still for a minute.
>
> Karen Hewitt,
> Learning Materials Workshop

Still, having children become familiar with the computer can provide an advantage for those entering the workforce in the year 2020. In doing so, however, software needs to be carefully chosen and screened

by teachers so that it is age-appropriate, and linked to the curriculum.

Implementation Issues

When children use manipulatives and play to learn core subjects such as math, the teacher's role naturally changes. Should a teacher intercede when children are arguing about size to indicate whose block tower is, in fact, bigger, or should she/he let the children decide? To what extent should the teacher control the activities available to children? Should the teacher's role be simply to set up a stimulating, colorful, and diverse environment or should she/he plan activities for the students to participate in? And if activities are planned, should the teacher intervene to make sure that students participate in them? These questions need further investigation.

While the role of play with manipulatives has been firmly established, there is still more to learn about implementation issues in the early childhood classroom. Additional field research and teacher experiences will need to guide developmentally appropriate practice (DAP) science, math, and technology education in order to create a clear picture of optimal DAP instruction.

Using Assessment to Learn About Children's Science Learning

The principles of developmentally-appropriate practice (DAP) are rooted in the understanding that each child develops at his/her own pace. Good teaching practice in the early childhood curriculum involves ongoing assessment—both to gauge the progress of each individual child, as well as to inform instructional practice.

Multiple Forms of Evidence

Developmentally-appropriate early childhood assessment in science centers around multiple forms of evidence gathered through the course of normal classroom activities. Types of evi-

dence include: observation; discussion; and analysis of students' drawings, written work, and concept maps. By analyzing multiple forms of evidence, teachers gain an understanding of children's learning styles, strengths, and weaknesses. In order to gain a sense of a student's progress, teachers must examine these multiple forms of evidence over a period of time (e.g., comparing the beginning of the year with the middle of the year).

> For true assessment, there really need to be multiple forms of evidence. The notion that any one piece of evidence at any one time can ever tell you a true picture of children's performance is inadequate and probably wrong.
> Jacqueline Jones, Educational Testing Service

Assessment Skills

Teachers need practice "reading" children's science work.[6] Conducting assessment around science curricula calls for documentation of both process and content. For example, a discussion following a hands-on exploration can help teachers assess whether children have ideas about concepts that underlie what they have experienced, whether there are inaccuracies that need to be clarified, and whether children are ready for new information. Open-ended questions are especially useful in this realm, to assess what children know and to spur their thinking.

Teachers must continually reflect upon what they document. Ideally, teachers have an opportunity to analyze evidence in consultation with colleagues who teach at other grade levels. This enhances a teacher's ability to sense where students are relative to peers in the same age range.

Perspective of the Parent and Child

Parents are an important part of the assessment process. In some cases, parents may provide insight into the child's performance, and may have observations of their own to contribute to the teacher's evidence. More likely, parents will be interested in the teacher's evaluation of their child and his or her progress during the year. It is also important to keep children involved in the assessment process, and to give children feedback about how and what they are learning.

> Learning is something that people do in all aspects of their lives and, in fact, to meaningfully assess learning you have to understand how the things that children do in school relate to the things they do at home, in afterschool programs, and at camp. Only in looking at someone's life do you really understand what meaningful learning is.
>
> Lynn Dierking,
> Institute for Learning Innovation

Standardized Testing

There is a disconnect between assessment as described above—using multiple forms of evidence (sometimes referred to as "authentic assessment"), and testing content knowledge through standardized tests. Authentic assessment is especially appropriate for gauging early childhood learning within the context of the classroom. In contrast, According to the Association of Childhood Education International, standardized testing is a questionable practice, particularly during the younger grades when children's growth is most uneven and idiosyncratic.[7]

Standardized testing, however, is an integral part of the educational experience for almost all children because it satisfies administrative and reporting concerns more efficiently than alternative assessment. A further benefit of standardized tests is that they provide teachers with a powerful source of research data that, which if properly used, can inform practice.[8] Thus, from a practical standpoint, teachers need to know how to help children successfully master these exams. Staff development that builds familiarity around test content and format and helps teachers create a comfort level for children has become a necessary reality. Making peace with standardized testing in no way compromises or lessens the need for the broad developmentally-appropriate approach to assessment described above. There is room for both types of assessment in the educational process.

> The good news is that science assessment, unlike reading and math, doesn't bring a long history of testing. Science presents an opportunity to really create new models for assessment.
>
> Edward Chittenden,
> Educational Testing Service

Implications for Teacher Education

In the context of school reform, it is essential to examine teacher preparation from the perspective of practice, content, and equity. Institutions of teacher education need to: better educate teachers to understand the process of learning; improve teachers' grasp of content, particularly in the areas of science and math; and engage them in the process of creating institutional change around issues

> All of the children who enter the workforce in 2020 will experience diversity in the workplace. They all will need to experience some curriculum, information, or approaches that will allow them to learn about and appreciate differences in their work and in their social interactions.
>
> Edward Greene,
> Lehman College, City University of New York

of diversity—a necessity if teachers are going to be able to educate today's young children for life and work in the global economy of 2020 and beyond.

Examining Practice

In terms of practice, the active learning, experiential approach based on developmentally appropriate practice (DAP) and principles of child development are valid methods for early childhood education. Teachers need to be trained to engage in child study as an integral part of their daily interaction with students—that is to observe, record and analyze children's activities as a means to understand how they learn and what they know.

Field Experience

Direct field work, when a student works in a classroom under the guidance of an experienced teacher, is another essential aspect of teacher preparation. Field experience should be with a model teacher, and there is a severe shortage of good placements. The typical twelve-week segment for the field experience is too short a period for observing the lead teacher, preparing and trying out lesson plans, learning the needs of individual children, and absorbing

> Between the child initiated play and the totally teacher directed activity there is a vast divide, and we are not really training teachers well to address that vast divide—to watch children when they play, to know or intuit when to intervene, how to intervene so that you are not interfering with the child's thought processes but extending them.
>
> Nancy Gropper, Bank Street College of Education

the nuances of school culture. However, in the current structure for teacher preparation, a longer field experience is difficult to administer. Whatever the field experience, it is enhanced by opportunities for self-reflection through journal writing, action research, or analysis of field experiences in terms of DAP.

Structure and Content

Turning to the issue of classroom structure and content, teachers need to be trained in how to set up activity centers in which children can learn through the use of engaging materials, with the teacher serving as facilitator and monitoring progress. While it is encouraging that there has been growth in this approach for pre-K classrooms over the past few decades, there is also an opposing trend to establish first- and second-grade type classrooms with more teacher-directed instruction at the kindergarten level.

> Not many of us have experienced the kind of environment for learning that we are trying to create. Very few of my students have learned the way I would like them to learn, or the way I would like them to teach.
>
> Karen K. Lind,
> University of Louisville

Teacher education institutions need to help preservice teachers understand how to select materials that support content. For example, lack of knowledge about the myriad learning possibilities of unit blocks has led to diminished use of these materials in the pre-K and kindergarten classrooms, where they were once a curriculum staple. Since unit blocks are an open-ended material that give children experience in geometry, physics, balance, symmetry, problem-solving, decision-making, creative-thinking, cooperative learning, and social/communication skills, to name just some of their attributes, teachers-in-training need hands-on

experience to gain awareness of their value, especially in the areas of math and science. Block building also adds immeasurably to the information children gain from other more narrowly-based math manipulatives.

Using the Natural Environment

Teaching preservice teachers how to use the natural environment for content is another area that needs attention. Exposing young children to life forms found in the everyday, nearby environment provides more meaningful content than kit-based science that may or may not relate to their immediate world, be that an urban, suburban, or rural setting. A square of grass, a bare city tree in winter, a concrete playground, all can be used to sharpen children's observation skills while enhancing their understanding of the natural world.

By exploring the everyday world, children can learn to think—to pose problems and to solve problems, perhaps the most essential skill for the 21st century. Through everyday activities children can develop process skills essential for science—sorting, classifying, measuring, comparing, documenting. Using their senses to explore their immediate environment, children will learn to observe phenomena, pose questions, experiment, seek answers, conduct age-appropriate research to find answers. Teachers can learn to harness students' natural curiosity.

Modeling Inquiry-Based Learning

Teacher education institutions must model inquiry-based learning in order to develop teachers who are comfortable teaching

children in this way. Teachers must learn how to ask open-ended questions instead of demanding "right answers." What does it look like? Tell me about it. How can you find out? Can you think of another way? These are all questions that will spur children to think and problem-solve in ways that memorized facts, which may quickly become obsolete, never will.

Confronting Inequity

Clearly, teacher education institutions have much to change in order to produce teachers who will successfully prepare *all* children for adulthood and work in the 21st century. But meaningful change cannot occur until the institutions themselves confront issues of inequity that are inherent in the very structure of higher education.

Institutional forms of bias stand as obstacles to children reaching their full potential, and schools of education have a role to play in creating institutional change. Teacher education courses must address institutional bias and equity issues, not in an *ad hoc* manner at the discretion of individual teachers, but in-depth as a full semester course and as a topic of faculty led seminars and conferences.

Science provides an example. Traditionally science has been the domain of white males. Others, such as children of color, all girls, children with disabilities, and children from low-income families, were not seen as "science capable" and, thus, were not given opportunities for instruction, scholarships, internships, and other ways up the scientific ladder. One can make a similar case for inequities in the field of mathematics.

Teacher education institutions need to prepare teachers to become advocates for equity in the public schools and early childhood centers where they will ultimately teach. To accomplish this, the first step is for faculty and administrators of teacher education institutions to engage in a process of self-reflection, confronting their own biases, and the effect these biases have on their teaching. Next, there must be a place in the teacher education curriculum where preservice teachers have the opportunity to go through a similar process. If this can occur in institutions of higher education that send teachers of young children into the field, *all* children will have equal educational opportunity.

> When we look at science, math, and technology, as when we look at any other content and process issue in education, one of the major obstacles that exists in schools of education today are equity issues. Institutional forms of bias stand as obstacles to children realizing their full developmental potentials. We need to prepare teachers to be initiators of the institutional change process.
> Carol Brunson Day, Council for Professional Recognition

Looking to the global future of the world of 2020, it is imperative that we educate teachers for the rich diversity of children they will teach. As a result, they will be prepared to educate children who know how to think, who are adept at recognizing and solving problems, and who can interact with ease with diverse people in the workforce.

Involvement of Parents and Family

Family involvement is of critical importance to children's educational competence and success, and the early childhood years are when home-school connections are the strongest. Through connections with families, educators learn what children already know when they enter school and acknowledge the importance of children's culture in terms of their knowledge base.

Parents as Partners

To begin, schools should view parents as partners. For example, parents play an important role in the social and emotional development of children, and current research has pointed to the importance of such development for early school success. Socially competent children thrive despite risk factors, such as poverty.[9] Also, a teacher's evaluation of a child's academic performance is often closely tied to how that child handles social

and emotional situations. Parents may not realize that what they are teaching their children about social skills can be key to their academic success once they reach school.

Parent involvement programs need to be proactive and positive. Often parents are contacted only when there is a problem, and as a result, many families feel disenfranchised rather than welcomed by their children's schools. Frequently these are the very families whose children are the least likely to receive a good science education—children who are poor, children of color, and children with disabilities.

> What parents are teaching children about social skills are key to their academic success—including math and science—once they reach school.
> Cybele Raver, Cornell University

Parents and Science

It is paradoxical that science, math, and technology—areas in which parents may feel particularly disenfranchised—provide a unique vehicle to empower parents. Parent involvement programs around science, math, and technology provide a meaningful way for families to be involved in their children's education. Such programs can affirm that parents know a lot more science than they think, that in fact they do science everyday, but they do not call it science. (It should be noted that the same can be said for *children's* science learning). Once parents realize their own science potential, they also realize that they can help their children's science learning.

Involvement in a curriculum area such as science is empowering for parents when they understand they have a real role to play in the learning process. Science provides an opportunity to let parents "play" and helps them to develop insights into the complex social and cognitive learning that goes on during children's play. Science can also illustrate the importance of child-centered and inquiry-based activities.

> Research has shown that parent involvement is a key indicator of children's learning and success in school. This is a disconnect to the real world, where often parental involvement is given just lip service.
>
> Merle Froschl,
> Educational Equity Concepts

In the long run, not only will science be good for family involvement, but family involvement will be good for science. Informed and involved parents will become advocates for more and better science, thus helping their own children and improving science education for all children in that school environment.

To more accurately immerse parents in science, we need to ask not only what parents *need* to know, but what parents *want* to know. Parents may feel disconnected from resources such as science centers and museums, not necessarily because of the cost (although that is certainly a factor) but because they do not know what is inside. Parents want to be the "experts" when they bring their children to science centers.

Parents both need and want to know about diverse role models, about specific math and science courses needed for pursuing careers, about the specific curriculum of their child's school, and

about national educational goals and standards. Many strategies have proven effective:

- involve parents and children in activities together
- engage parents in science inquiry that is fun
- use inexpensive, culturally familiar materials
- highlight relevant television shows or museum/community activities
- provide activities to do at home
- offer family science events
- conduct outreach in the family's dominant language.

> Parents must have more input into the form and content of science materials and programs targeted to them if these efforts are to be successful.
> Judy Kass, American Association for the Advancement of Science

Ongoing and effective communication between teachers and families overcomes institutional barriers and makes parents and other family members an integral part of their children's education. This will not happen without a concerted effort—but it will pay off in terms of competence in science, math, and technology for today's kindergartners and for the workforce of 2020.

Today's Kindergarten, Tomorrow's Workplace

The kindergarten class of 2000 will become the workforce of 2020 and beyond. What kind of workplace will these children find and what skills will they need? And what is the role of elementary education in preparing these children for their future roles in the labor force?

A Portrait of the Workplace in the Year 2020

Since the middle of the 20th century, the US economy has shown a steady shift away from its traditional manufacturing base towards a growing dependence on service-based industries. Services is now the leader in both production and employment.

In 1955, manufacturing accounted for nearly 30% of the nation's gross domestic product (GDP), and services for just more than 8%. By 1997, the roles had reversed, with services accounting for 20% of GDP as opposed to manufacturing's 17%. This trend is expected to continue through the first half of the new century.

The shift is even more pronounced from the point of view of employment. Manufacturing and services each employed about 25 million workers in 1988. Ten years later, service-sector employment had grown to nearly 37 million while manufacturing jobs remained almost stagnant. By 2008, there are expected to be nearly 50 million service workers, but still only about 26 million manufacturing workers.[10]

Another rapidly growing subset of the economy is high-technology industries, which include both manufacturing- and service-based industries. High technology industries directly employed 10 million workers in 1998. By 2008, a growth of 30% (3 million jobs) is projected-nearly twice the projected national average job growth rate. About 2 million of those new jobs will be in the computer and data processing services industry.[10, 11]

Workers involved directly in these high-tech industries represent only the tip of the iceberg. As businesses move towards greater globalization and Internet presence, high-tech workers are in demand in every industry. Including technology-oriented workers and workers in non high-tech industries dependent on purchases from high-tech industries adds another 6 million to the 1998 high-tech workforce.

A Portrait of the Workforce in the Year 2020

The overall aging of the baby-boom generation (persons born between 1946 and 1964) combined with increasing participation rates of older workers will push the median age of the workforce to record levels in the coming decade. By 2008, the median age of the nation's workforce is expected to be 40.7 years, up from 35.9 in 1988 and 38.7 in 1998. But while the workforce will grow older in terms of median age, it will grow younger based on proportion: for the first time in a quarter century, the youth labor force (aged 16 to 24 years) is expected to grow faster than the labor force as a whole.[10]

Women and minority populations will also grow as a fraction of the workforce. Non-Hispanic whites will continue to be the largest sub-group of the labor force, albeit with a slowly shrinking share projected to remain above 70% through 2008. Additionally, the Hispanic labor force is expected to grow larger than the African-American labor force for the first time ever in the coming decade.

The true hallmarks of the future workplace may well prove to be increasingly frequent job changes and shorter job tenures. Job tenure (the length of time an employee has been working for his or her current employer) for men in all age categories fell between 1983 and 1998. Service occupations (where job growth is occurring) have the lowest job tenure among the major occupational groups.[12] And a recent popular article claims that the average 32-year-old in America has already worked for 9 different firms. Indeed, proponents of the "new economy" endorse job- and business-"churning" as a requisite for a healthy, competitive economy.

Being Prepared for 2020

Adaptability and flexibility will be key characteristics of successful members of the workforce of 2020. Increasingly diverse coworkers, a churning job market, and increasingly rapid technical advances will reward workers who can learn quickly and train others quickly. There is growing consensus that adaptability and flexibility will be more important indicators of future success in the workplace than technical skills.

> There will be a premium on the social ability to get along with different groups and an older workforce. You need flexibility, you need social skills, and you need a supportive state and local community that's going to keep putting money into education to keep competitive with other parts of the country, because change will come rapidly and people will need to continually retrain.
> Rae D. Rosen, Federal Reserve Bank of New York

Projections from the Bureau of Labor Statistics show that even with the high growth rate of jobs in high-tech industries, the overall educational profile of the workforce is not expected to change greatly over the next decade. About 63% of total job openings between 1998 and 2008 will be in jobs requiring only on-the-job training. Another 14% will require some vocational training, related work experience, or an associate degree, and another 14% in jobs requiring bachelor's degrees.[10]

According to the National Science Foundation, employers are already looking for workers who can think critically, reason quantitatively, communicate effectively, find needed information, and interact productively with coworkers.[13] The National Academy of Sciences explains that there is an overarching need for employees who can continuously "adapt, adjust, and re-educate themselves

to remain productive in a changing environment." The projected changes in the workforce and workplace will only make these skills more important.[14]

Starting on the Right Track...

What core skills will help a child become proficient in the art of workplace adaptability? Literacy across genres and scientific reasoning lay a good foundation on which the art can be developed. These are subjects that already exist in current curricula, but which may benefit from greater attention. Kindergarten is indeed not too early to start laying a solid foundation for a child's future success in the workforce. In particular, focusing on literacy and inquiry skills will help children develop core competencies that will enable them to be productive, adaptable workers. Pedagogical approaches such as developmentally appropriate practices and inquiry-based learning offer frameworks for teaching these skills.

> Conjectures about the future are hazardous. It would not be a good idea to change curricula based on the details of workforce and demographic predictions. Things are likely to change in unpredictable ways. Let us focus on fundamentals.
>
> Rodney Nichols,
> New York Academy of Sciences

...Builds a Foundation for Future Success

Literacy standards in the early grades do focus on students' reading and writing across genres, but teachers need to spend additional time helping students with the skills of talking and negotiating. In most elementary classrooms, students speak only in response to specific questions—rarely are children given an oppor-

tunity to talk for extended periods of time, for example, by giving brief presentations to their classmates.

Science, when taught as a system of inquiry and problem solving, encourages critical thinking and teamwork. This gives students a chance to develop both "hard" technical skills and "soft" social skills. Just as giving brief presentations allows a child to gain first hand experience in educating or "training" their peers, approaching science in the context of inquiry allows a child to make first hand decisions about how to adapt and hone her approach to solving a problem.

The workplace of 2020 will include an increasingly representative cross-section of the American population, in terms of age, ethnicity, and gender. This, along with more frequent job changes and advancing technology, will make adaptability and communication the currencies of a successful workforce. Teaching today's kindergartners cross-cutting literacy and scientific inquiry skills can help us encourage lifelong learners with inquisitive minds eager to meet the challenges of the economy of 2020.

Issues for Further Exploration

At the conference a number of key issues arose and resonated throughout several of the sessions. These issues need additional analysis, discussion, and review. Each could be the topic of a future seminar or study.

1. Educating Pre-Service Teachers - Teachers need to be experts in a wide variety of areas, including child development, specific subjects, and pedagogy. In addition, teachers clearly need practice-teaching experience under the guidance of model teachers.

How is it possible to fit all of these needs into the teacher certification program? What are the highest priorities? How do we provide professional development for teachers that takes into account their need for interaction with colleagues, time for self-reflection, engagement in child study, and ongoing skill development? What needs to be done to improve teacher grasp of

science, math, and technology content? How do we engage teacher education institutions in the process of educational reform?

2. **Integrating Science, Math, and Technology into Early Education** - What are the developmentally-appropriate ways to bring science, math, and technology into the early childhood classroom? What are the connections between children's play and science, math, and technology learning? What is the appropriate amount of teacher involvement in meaningful play and curriculum planning? How does the cognitive stage of a young child relate to his or her ability to understand math and science concepts? How can blocks, manipulatives, outdoor time, and other early childhood activities be used for effective SMT instruction?

How do we articulate the importance of constructivist learning for young students to policy/decision-makers and parents? How do we reconcile the divide between proponents of authentic assessment and standards-based testing, which is particularly inappropriate at the early childhood level? What needs to be done to make parent involvement an integral part of SMT education reform, beginning in early childhood?

3. **Literacy through SMT** - We know from case studies that science inquiry is an effective literacy tool. How can educators be made aware of how science supports many of the social competencies that are seen as important for workforce success?

4. **Technology** - Given that technology is an ever-important part of the workforce and the economy, what is the role of technology and computers in the early childhood classroom? When is it developmentally-appropriate for children to be using computers and what is the best way for young students and computers to interact? How does this relate to the cognitive stages of young children?

5. **Equity and Access** - How do we bridge the gap between what we know about high quality, effective early childhood education and how few programs children are attending meet that standard? How can the entrenched and institutionalized gender, racial/ethnic, disability, and class biases of the university be addressed?

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14. Committee on Science, Engineering, and Public Policy, National Academy of Sciences, *Reshaping the Graduate Education of Scientists and Engineers* (Washington, DC: National Academy Press, 1995).

Related Papers

Math, Science and Technology in
Early Childhood Education
by
Barbara T. Bowman
Co-Founder and President
Erikson Institute for the Advanced Study
in Child Development

Mathematics and Computers for Young Children
by
Douglas H. Clements
State University of New York at Buffalo

Designing Meaningful Assessments for Young Children
by
Lynn D. Dierking, Ph.D.
Associate Director
Institute for Learning Innovation
Annapolis, MD 21401

Work/Play: Manupulatives/Toys
Implications for Learning
by
Karen Hewitt
President and Designer
Learning Materials Workshop

Early Childhood Teacher Education:
Reflections on Best Practices as
a Gateway to the Future
by
Nancy Grooper
Faculty Member and Advisor
Bank Street College
Graduate School of Education

Implications for Early Childhood Teacher Education:
Creating an Environment for Science
by
Dr. Karen K. Lind
Professor of Science Education
School of Education
University of Louisville

Inclusive Early Childhood Education:
A Position Paper
by
Dr. Valerie Lava
Assistant Professor of Special Education
Department of Teaching and Learning
Long Island University

Conference Agenda

Educating for the Future:
Connecting Kindergarten in the Year 2000
to the Workforce of 2020

Co-convened by Educational Equity Concepts, Inc.
and the New York Academy of Sciences
June 15-16, 1999
New York, New York

June 15, 1999

11:30AM Convene

12:00 - 1:00PM Lunch

Welcome: *Rodney W. Nichols*
President and CEO
New York Academy of Sciences

1:00 - 2:30PM Panel One - *What are developmentally-appropriate ways to expand young children's understanding of the world?*

Moderator: *Barbara Sprung*, Co-Director
Educational Equity Concepts, Inc.

Presenters: *Barbara T. Bowman*, Co-Founder and President, Erikson Institute for the Advanced Study in Child Development

Jerlean E. Daniel, Associate Professor, Program in Child Development and Child Care, University of Pittsburgh, School of Social Work
Valerie Lava, Assistant Professor of Special Education, Long Island University

Respondent: *Barbara D. Finberg*, Vice President, MEM Associates

The panelists set the early childhood context in which issues of Transition from Childhood to the Workforce (TCW) should be framed—developmentally appropriate practice, connectedness between family/child/teacher, constructivist curriculum, professional development for teachers of young children, and heterogenous grouping in which children with and without disabilities learn together in an inclusionary environment.

2:30 - 4:15PM Panel Two - *How can we help all children develop a broad range of skills that will prepare them for later competency and success in S/M/T?*

Moderator: *Ellen Wahl*, Senior Scientist, Education Development Center

Presenters: *Douglas H. Clements*, Professor of Mathematics and Computer Education, State University of New York at Buffalo
Herbert P. Ginsburg, Jacob H. Schiff Professor of Psychology and Education, Teachers College, Columbia University

Karen Hewitt, President and Designer, Learning Materials Workshop

Respondent: *Mark Miksic*, Associate Professor of Physics and Astronomy and Director of the Science Teachers Careers Program, Queens College of the City University of New York

The panel considered ways in which to adapt developmentally appropriate practice to the teaching of science, math, and technology for young children. Panelists presented information on recent research focussing on the math and science learning that occurs in children's play, and discussed the kinds of manipulatives (blocks in particular) that stimulate childrens' math and science learning, curiosity, and experimentation..

4:30 - 6:00PM Panel Three - *How do we assess the learning that is taking place?*

Moderator: *Linda Colón*, Coordinator, Science Programs, Educational Equity Concepts, Inc.

Presenters: *Lynn D. Dierking*, Associate Director, Institute for Learning Innovation
Jacqueline Jones, Senior Research Scientist, Educational Testing Service

Respondent: *Edward Chittenden*, Principal Research Psychologist, Educational Testing Service

The definition of assessment ascribed to by the panel was a broad one that was in keeping with the "whole child" approach

of early childhood education. Assessment was defined as the process of analyzing pieces of evidence gathered in a variety of places—the classroom, home, afterschool programs, camps, museums, etc. Methods of assessment for young children include teacher observations, talking with children, analyzing children's drawings, and videotaping children in action. The real materials for assessment are those found in classroom and homes, the objects children use in their daily lives. Panelists discussed the need for parents to be an integral part of the assessment process, since so much learning takes place within the home.

6:00 - 8:00PM Reception/Dinner

June 16, 1999

8:30AM Convene/Breakfast

9:00 - 10:30AM Panel Four - *What are the implications for teacher education?*

Moderator: *Ellen Rubin*, Coordinator, Disability Programs, Educational Equity Concepts

Presenters: *Nancy Gropper*, Faculty Member and Advisor, Bank Street College, Graduate School of Education
Karen K. Lind, Professor of Science Education, School of Education, University of Louisville
Carol Brunson Day, President and

CEO, Council for Early Childhood Professional Recognition

Respondent: *Edward Greene*, Assistant Professor, Graduate Program, Department of Early Childhood and Elementary Education, Lehman College, City University of New York

The panel addressed teacher education from the perspective of practice, content, and equity. A central theme was how to better educate teachers to understand the process of learning, improve teachers grasp of content, particularly in the areas of science and math, and how to create institutional change around issues of diversity—a necessity if teachers are going to be able to educate today's young children for life and work in the global economy of 2020 and beyond.

10:30 - 12:00PM Panel Five - *What do parents and other family members need to know to help their children gain competence in S/M/T?*

Moderator: *Maryann Stimmer*, Science Associate, Educational Equity Concepts, Inc.

Presenters: *Cybele Raver*, Assistant Professor of Human Development and Family Studies, Cornell University

Judy Kass, Project Director, Directorate for Education and Human Resources, American Association for the Advancement of Science

Respondent: *Merle Froschl*, Co-Director, Educational Equity Concepts, Inc.

The panel addressed how to maximize home/school connections to help children gain competence in science/math/technology, with an emphasis on strategies for fostering parent involvement in their children's science education. Recent research that points out the importance of social and emotional development of children in terms of school success was discussed in terms of the need for schools to reinforce and acknowledge what families do well in terms of raising their children, particularly families of children at risk.

12:00 - 1:00PM Lunch

1:00 - 3:00PM Panel Six - *What are the implications of future economic and demographic trends for early childhood education?*

Moderator: *Rodney W. Nichols*, President and CEO, New York Academy of Sciences

Presenters: *Rae D. Rosen*, Senior Economist, The Federal Reserve Bank of New York
Brian Min, Research Associate, Department of Policy Programs, New York Academy of Sciences

Respondent: *Rodney W. Nichols*, President and CEO, New York Academy of Sciences

The panelists presented a portrait of the workplace and the workforce in the year 2020. They emphasized the shift from a manufacturing base toward a service economy pointing out that information technology is currently the most important growth sector, and noted that while there are no major demographic shifts anticipated, new entrants to the labor force are more likely to be minority and female. The panel indicated that good sci-

ence education would prepare children for the skills identified as key for the future workforce: critical thinking, quantitative reasoning, effective communication, and the ability to interact with others.

3:15 - 4:00PM Meeting Summary/Closure

Lori Skopp, Director of Education,
New York Academy of Sciences

Participant List

Barbara T. Bowman
Co-Founder and President
Erikson Institute for the Advanced Study in Child Development
420 North Wabash Avenue, 5th Floor
Chicago, IL 60611
Tel: 312.755.2275, ext. 2275
Fax: 312.755.2255
e-mail: bbowman@luc.edu

Edward Chittenden
Principal Research Psychologist
Educational Testing Service
Mail Stop 11-P, Rosedale Road
Princeton, NJ 08541-0001
Tel: 609.734.5658
Fax: 609.734.1755
e-mail: echittenden@ets.org

Douglas H. Clements
Professor of Mathematics and Computer Education
State University of New York at Buffalo
501 Capen Hall
Buffalo, NY 14260
Tel: 716.689.3788
Fax: 716.645.3161
e-mail: clements@acsu.buffalo.edu

Linda Colón
Coordinator, Science Programs
Educational Equity Concepts, Inc.
114 East 32nd Street
New York, NY 10016
Tel: 212.725.1803
Fax: 212.725.0947
e-mail: information@edequity.org

Jerlean E. Daniel
Associate Professor of Child Development
School of Social Work, University of Pittsburgh
3939 O'Hara Street, Room 803 LRDC
Pittsburgh, PA 15260
Tel: 412.624.6356
e-mail: SSWJD+@Pitt.edu

Carol Brunson Day
President and CEO
Council for Early Childhood Professional Recognition
2460 16th Street, N.W.
Washington, DC 20009-3575
Tel: 202.265.9090
Fax: 202.265.9161
e-mail: carolp@cdacouncil.org

Lynn D. Dierking
Associate Director
Institute for Learning Innovation
166 West Street
Annapolis, MD 21401
Tel: 410.268.5149
Fax: 410.268.7179
e-mail: dierking@ilinet.org

Barbara D. Finberg
Vice President
MEM Associates
521 Fifth Avenue, Suite 1801
New York, NY 10175
Tel: 212.297.0500
e-mail: bdf-memassoc@mindspring.com

Merle Froschl
Co-Director
Educational Equity Concepts, Inc.
114 East 32nd Street
New York, NY 10016
Tel: 212.725.1803
Fax: 212.725.0947
e-mail: information@edequity.org

Herbert P. Ginsburg
Jacob H. Schiff Professor of Psychology and Education
Teachers College, Columbia University
542 Grace Dodge Hall
525 West 120th Street
New York, NY 10027
Tel: 212.678.3000
e-mail: hpg4@columbia.edu

Edward Greene
Assistant Professor, Graduate Program
Department of Early Childhood and Elementary Education
Lehman College, City University of New York
Home address: 23 Raleigh Road
Kendall Park, NJ 08824
Tel: 732.398.0593
Fax: 732.398.1461
e-mail: ed313@aol.com

Nancy Gropper
Faculty Member and Advisor
Bank Street College, Graduate School of Education
Home address: 313 West 103rd Street
New York, NY 10025
Tel: 212.662.4046
Fax: 212.316.9105
e-mail: GropperN@aol.com

Karen Hewitt
President and Designer
Learning Materials Workshop
274 North Winooski Avenue
Burlington, VT 05401
Tel: 802.862.0112
Fax: 802.862.0794
e-mail: LMWblocks@aol.com

Fredrica Jarcho
Program Officer
The Greenwall Foundation
2 Park Avenue
New York, NY 10016
Tel: 212.679.7266
e-mail: fjarcho@mindspring.com

Jacqueline Jones
Senior Research Scientist
Educational Testing Service
Mail Stop 11-P, Rosedale Road
Princeton, NJ 08541-0001
Tel: 609.921.9000
Fax: 609.734.1090
e-mail: jjones@ets.org

Judy Kass
Project Director
Department of Education and Human Resources
American Association for the Advancement of Science
1200 New York Avenue
Washington, DC 2005
e-mail: jkass@aaas.org

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Valerie Lava
Assistant Professor of Special Education
Long Island University
Department of Teaching and Learning
1 University Place, Room M205
Brooklyn, NY 11201
Tel: 718.488.1103
e-mail: vlava@liu.edu

Karen K. Lind
Professor, Science Education
University of Louisville
School of Education
Louisville, KY 40292
Tel: 502.852.0586
Fax: 502.852.0726
e-mail: klind@louisville.edu

Mark Miksic
Associate Professor of Physics and Astronomy
Director of the Science Teachers Careers Program
The City University of New York - Queens College
Flushing, NY 11367
Tel: 718.997.3379
Fax: 718.997.3349
e-mail: mark_miksic@qc.edu

Brian Min
Research Associate
Department of Policy Programs
New York Academy of Sciences
2 East 63rd Street
New York, NY 10021

Rodney W. Nichols
President and CEO
New York Academy of Sciences
2 East 63rd Street
New York, NY 10021
Tel: 212.838.0230, ext. 202
Fax: 212.753.3479
e-mail: nichols@nyas.org

Cybele Raver
Assistant Professor of Human Development and Family Services
Cornell University
MVR Hall
Ithica, NY 14853
Tel: 607.225.4123
e-mail: ccr4@cornell.edu

Rae D. Rosen
Senior Economist
Economic Studies
The Federal Reserve Bank of New York
33 Liberty Street
New York, NY 10045
Tel: 212.725.5000

Ellen Rubin
Coordinator, Disability Programs
Educational Equity Concepts, Inc.
114 East 32nd Street
New York, NY 10016
Tel: 212.725.1803
Fax: 212.725.0947
e-mail: information@edequity.org

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Lori Skopp
Director of Education
New York Academy of Sciences
655 Madison Avenue, 16th Floor
New York, NY 10021
Tel: 212.838.6727, ext. 630
Fax: 212.355.2781
e-mail: lskopp@nyas.org

Barbara Sprung
Co-Director
Educational Equity Concepts, Inc.
114 East 32nd Street
New York, NY 10016
Tel: 212.725.1803
Fax: 212.725.0947
e-mail: information@edequity.org

Maryann Stimmer
Science Program Associate
Educational Equity Concepts, Inc.
114 East 32nd Street
New York, NY 10016
Tel: 212.725.1803
Fax: 212.725.0947
e-mail: information@edequity.org

Ellen Wahl
Senior Scientist
Education Development Center
96 Morton Street, 7th Floor
New York, NY 10014
Tel: 212.807.4229
Fax: 212.807.8804
e-mail: ewahl@edc.org

About Educational Equity Concepts, Inc. and the New York Academy of Sciences

Educational Equity Concepts, Inc. (EEC) is a national not-for-profit organization founded in 1982 to promote equal educational opportunity through programs and materials that counteract bias due to gender, race/ethnicity, disability and socioeconomic status. From its inception, EEC has addressed the under-representation in science of girls, children of color, children from low-income families, and children with disabilities.

EEC recognizes that science study is an arena where inequities based on gender, race/ethnicity, disability, and socioeconomic status converge to limit opportunities for individual students

and shrink the pool of future scientific talent for our country. The organization's work in science equity began in 1984 with *What Will Happen If...young Children and the Scientific Method*, an early elementary curriculum with a strong focus on inquiry-based physical science activities and gender equity. In 1986, *Playtime is Science* (PS), a parent/child activity program, was developed locally in New York City schools. In 1992, based on its success in New York City, EEC received a three-year grant from the National Science Foundation (NSF), for three PS national pilot sites, and funds from the Toyota USA Foundation for a fourth pilot site. The NSF funding resulted in a PS materials package which is now being disseminated nationally. A three-year grant from the DeWitt Wallace-Reader's Digest Fund provided support for the development of an implementation and dissemination network for the program through the Desegregation Assistance Centers (DACs) in the ten Federal Regions.

With funding from the NSF Program for Women and Girls and from New York City private foundations, EEC developed *Afterschool Science PLUS* to extend its science work from school-based settings into the informal sector of afterschool agencies. Currently, with two-year support from the NSF Program for Persons with Disabilities, EEC is developing *Playtime is Science for Children with Disabilities*, to ensure the full inclusion of children with disabilities.

The New York Academy of Sciences, founded in 1817, is an independent not-for-profit institution. The Academy's mission is to advance understanding of science and technology and to lead in

using that knowledge to help solve societal problems—within the New York region and around the world. A leader in the field of science policy, the Academy sponsors frequent conferences, roundtables, and seminars to synthesize varying perspectives on complex issues.

The Academy has played a major role in science education since the mid-1960's through a variety of programs for teachers, students and schools. In 1997, the New York Academy of Sciences launched Scientific Process, Practice, and Presentation: Applying Resources and Knowledge (SP^3ARK). SP^3ARK is a three-year NSF-funded program that is being piloted in four New York City middle schools. SP^3ARK focuses on improving middle school science by helping teachers to integrate scientific inquiry into the curriculum.

As part of a broad initiative sponsored by The Starr Foundation, "Technology in Economic Development Across the Tri-State Region: Improving Analysis and Taking Action," the Academy is increasingly focusing attention on issues of workforce development, particularly in the New York/New Jersey/Connecticut region. Throughout the new five years, the Academy will work closely with institutions already active in pursuing the region's economic goals.

New York Academy
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2 East 63rd Street
New York, NY 10021

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